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Analysis of Magneto-acoustic Waves Propagating Through Transverse Magnetic Field Under the Influence of Radiative Cooling

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ABSTRACT

This paper studies the effect of radiative condensation on Jeans instability of self-gravitating dusty plasma in the presence of transverse magnetic field. It is assumed that medium is made of three component plasma having electrons, ions and charged dust grains. The Ions are assumed to be inertialess and having infinite large thermal conductivity. The electrons are also assumed to be inertialess but having finite large thermal conductivity. The external magnetic field is aligned along the z-direction. With the help of linearized perturbation equations, a dispersion relation is obtained. The dispersion relation is solved numerically and effect of various factors on the growth rate of the instability is obtained. It is found that the cooling effect of the system has a stabilizing influence on the growth rate of instability.

Keywords: Magneto-acoustic, waves, transverse magnetic field.

1. INTRODUCTION

One of the most important phenomena in astrophysical problem is gravitational collapse of neutral dust grains and since the first stability analysis given by Jeans[1] and he has derived the expression for maximum rise of a uniform gravitating mass which is stable to small fluctuations in density. The increasing importance of dusty plasma in relation to understand the problems of star formation has attracted the

attention of scientists in the recent past. The interplanetary space is full of dust known as "interplanetary dust". The existence of interplanetary dust particles was known from the zodiacal light. The zodiacal light is due to dust grains distributed throughout the inner solar system, with the strong contributions from the asteroid belt[2]. Dust grains are massive and their sizes range nanometers - millimeters. If the dust grains are charged, the dynamical behavior self-gravitating mass is significantly modified due to interplay between gravitational and electrostatic forces.

The present study examines the effect of radiative condensations on Jeans instability of self-gravitating dusty plasma in the presence of magnetic field. It is assumed that plasma is extremely heated and thermal loss due to radiative cooling of the electrons. The phenomenon of thermal instability arising due to heat-loss mechanism in dilute plasma has been discussed by several investigators [Field[3], Dwivedi *et al.*[4], Pandey and Kumar[5], Mamum[6], Gupta *et al.*[7] and Bora and Talwar[8]]. Recently, Prajapati *et al.*[9] have investigated the self gravitational instability of rotating viscous hall plasma with arbitrary radiative heat-loss functions and electron inertia. Pensia *et al.*[10] have discussed the magneto-thermal instability of self gravitating viscous hall plasma in the presence of suspended particles. Kim and Narayan[11] have investigated the thermal instability in clusters of galaxies with conduction taking the role of effect of radiative heat-loss function. Inutsuka *et al*.[12] have studied the propagation of shock waves in a warm neutral medium taking into account radiative heating and cooling, thermal conduction and viscosity terms. Menou *et al.*[13] have discussed the importance of radiative effect in the Sun's upper radiative zone. Stiele *et al.*[14] have investigated the problem of clump formation due to thermal instability in weakly ionized plasma. Fukue and Kamaya[15] have discussed the problem of thermal instability considering the effects of ion-neutrals friction, radiative cooling functions and magnetic field. Shadmehri and Dib[16] have investigated the thermal instability in magnetized partially ionized plasma. To study the interstellar gas dynamics it has been established as a fact that the magnetic field plays an important role in the star formation and molecular cloud condensation process. In the interstellar medium (ISM), a large amount of energy is injected by the stars, which leads to the formation of shock waves, they become large amplitudes hydromagnetic Alfven waves. Magnetic field can provide pressure support and inhibit the contraction and fragmentation of interstellar clouds. The magnetic field interact directly only with the ions, electrons and charged grains in the gas. Collisions of the ions with the predominantly neutral gas in the clouds are responsible for the indirect coupling of the magnetic field to the bulk of the gas [Langer[17]]. Chhajlani and Parihar [18] have studied the magneto-gravitational instability of self-gravitating dusty plasma. Rao[19] have studied the magnetoacoustic modes in magnetized dusty plasma. Dwivedi and Das[20] have investigated the neutral induced low frequency instability in weakly ionized magnetized plasma. Mahanta *et al.*[21] have discussed the dynamics of magnetized gravitating dusty plasma. Recently, Pensia *et al.*[22] have discussed the role of magnetic field in contraction and fragmentation of

interstellar clouds. Thus the aim of the present paper is to study the problem of gravitational collapse of charged dust grains and the plasma and the excessively heated and thermal loss due to radiative cooling of the electrons becomes important in the presence of magnetic field.

From the above studies, we find that magnetic field and the radiative cooling of the electrons on the gravitational collapse of the dust grains are the important parameters to discuss the gravitational instability of plasma. Thus, in the present problem we investigate the effects of radiative cooling of the electrons on the gravitational collapse of the dust grains in the presence of the magnetic field. It is assumed that radiative cooling of the ions or dust grains due to this process is negligible. For our convenience, we have account the Jeans swindle for studying the linear stability of infinitely homogeneous dusty plasma system. Thermal equilibrium of the electrons is achieved by the balance of thermal conduction and radiative cooling through the trace elements. The analysis caries that the radiative cooling suppresses the gravitational collapse through acoustic stabilization terms.

2. BASIC EQUATIONS AND STABILITY ANALYSIS

We consider a three-component plasma having electrons, ions and charged dust gains. In the realistic situation the size, the mass and the charge of the dust grains may have different values. The charge to mass ratio of a dust particle may vary from one grain to another but for simplicity it is assumed that dust grains have uniform mass, behave like point charges and neither break up nor undergo collisions. For further simplification it is assumed that there is no charge fluctuation. Our assumptions are similar to those of the considered earlier by Dwivedi[3] and Tystovich and Havens[23].

Consider a three-component fluid model of dusty plasma consisting of electrons, ions and charged dust particles embedded in an external magnetic field. We assume that the magnetic field is aligned along the Z direction i.e.

$$\vec{\mathrm{B}} = B_0\hat{z} \tag{1}$$

In general, the dust grains have distributions in mass, size and charges with variable changing time scales but we shall assume here that the grain mass m_{d} is constant. We shall also assume that the grains confine themselves to fixed spherical grains of radius a and charge q_{d}. The self-gravitation for dust particles is considered by taking Poisson equation. The self-gravitational contribution of electrons and ions is not considered in the present analysis because it is assumed that both ions and electrons are inertia-less. It is assumed that the ions have infinity large thermal conductivity and, therefore, they are considered to be in thermal equilibrium but the electrons have finite thermal conductivity $K^2V_{\mathrm{the}}^2/\nu_{\mathrm{e}}\sigma = 1$, where $V_{\mathrm{the}} = (T_{\mathrm{e}}/m_{\mathrm{e}})^2$, ν_{e} is the electron collision frequency and σ is the growth rate and radiative cooling through the trace elements. Consequently, the electrons are not in thermal equilibrium.

The dynamics of the three-component fluid is governed by the following equations. On the slow time scale of the dust dynamics, the ions densities are given by the Boltzmann distributions:

$$n_i = n_{i0} \exp(-e\Phi / T_i) \tag{2}$$

The dynamics of the electron is described by the following set of equations:

$$0 = en_e \nabla\Phi - \nabla p_e \tag{3}$$

$$\left(\frac{3}{2}\right) n_e \frac{\partial T_e}{\partial t} + p_e \nabla . \vec{v}_e = \chi \nabla^2 T_e - \mathcal{L}(n_e, T_e) \tag{4}$$

$$\frac{\partial n_e}{\partial t} + \nabla . (n_e \vec{v}_e) = 0 \tag{5}$$

where χ and $\mathcal{L}$ are thermal conductivity and heat-loss due to radiative cooling respectively.

The dynamics of the dust grains is described by the following set of equations:

$$D\vec{v}_d = -\frac{q_d}{m_d}\left[\nabla\Phi - \frac{\vec{v}_d \times \vec{B}}{C}\right] - \nabla\psi \tag{6}$$

$$\frac{\partial n_d}{\partial t} + \nabla . (n_d \vec{v}_d) = 0 \tag{7}$$

where

$$D = \frac{\partial}{\partial t} + \vec{v}_d . \nabla \tag{8}$$

denotes the convective derivative and

$$\nabla = \frac{\partial}{\partial x}\hat{x} + \frac{\partial}{\partial y}\hat{y} + \frac{\partial}{\partial z}\hat{z} \tag{9}$$

Poisson equation for electrostatics and gravitational fields are respectively given as

$$\nabla^2\Phi = -4\pi \left[e(n_i - n_e) + q_d n_d\right] \tag{10}$$

$$\nabla^2\psi = -4\pi G m_d (n_d - n_{d0}) \tag{11}$$

where $n_j, \vec{v}_j, m_j$ and T_j are respectively the total number density, velocity, mass and temperature of the particle species (j- for electron, i- for ion and d- for dust grain).

We consider the quasineutral equilibrium i.e.

$$q_d n_{d0} + en_{i0} - en_{e0} = 0 \tag{12}$$

In this equilibrium there is no electric field and the free energy is solely due to gravitational field of the self-gravitating dust grains. However invoking Jeans swindle, the zeroth order gravitational field is assumed to play no role in the equilibrium. Thus we consider the dusty magnetized plasma characterized by

$$\psi_0 = 0,\ \Phi_0 = 0,\ \vec{v}_{d0} = \vec{v}_{e0} = \vec{v}_{i0} = 0 \tag{13}$$

Thermal equilibrium of the electrons is described by the following equation

$$\mathcal{L}_0(n_{e0}, T_{e0}) + \chi\nabla^2 T_{e0} = 0 \tag{14}$$

3. PERTURBATION STATE

Let the equilibrium state be perturbed then, every variable Q(r,t) may be expressed as

$$Q(x, y, z, t) = Q_0(z) + Q_1(x, y, z, t) \tag{15}$$

Here Q stands for Φ, ψ, n_i, n_e, n_d, e , where Q_0 is the value of Q at t = 0 and Q_1 in an infinitesimal increment of Q due to perturbation.

By the use of the expansion (15) for the fluid model of the dusty plasma system, the linearized perturbation equations are given as

$$n_{i1} = n_{i0}\frac{e\Phi_1}{T_i} \tag{16}$$

$$n_{ei} = n_{e0}\left(\frac{e\Phi_1}{T_e} - \frac{T_{el}}{T_{e0}}\right) \tag{17}$$

$$\left(\frac{3}{2}\right) n_{e0}\frac{\partial T_{el}}{\partial t} = \chi\nabla^2 T_{el} - \frac{\partial \mathcal{L}_0}{\partial n_{e0}} n_{el} - \frac{\partial \mathcal{L}_0}{\partial T_{e0}} T_{el} \tag{18}$$

$$\frac{\partial \vec{v}_{dl}}{\partial t} = -\frac{q_{d0}}{m_d}\left(\nabla\Phi_1 - \frac{\vec{v}_{dl}\vec{B}_0}{C}\right) - \nabla\psi_1 \qquad (19)$$

$$\frac{\partial n_{dl}}{\partial t} + n_{d0}\nabla.\vec{v}_{dl} = 0 \qquad (20)$$

$$\nabla^2\Phi_1 = -\,4\pi\left[e\left(n_{il} - n_{el}\right) + q_d n_{dl}\right] \qquad (21)$$

$$\nabla^2\psi_1 = 4\,\pi\,G\,m_d n_{dl} \qquad (22)$$

4. DISPERSION RELATION

Let us assume that all the perturbed quantities vary as exp $(-i\omega t + i\boldsymbol{K.r})$, where ω is the frequency of harmonic disturbances and K is wave number.

Using expression (23) and simplifying equation (17) and (18) we obtain

$$n_{el} = \frac{n_{e0}e\Phi_1}{T_{e0}}\left(1 - \frac{i\mathcal{L}_n}{\Omega}\right) \qquad (23)$$

where

$$\Omega=\left(\frac{3}{2}\right)\omega+i\chi K^2-i\mathcal{L}_t,\ \mathcal{L}_n=\frac{1}{T_{e0}}\frac{\partial\mathcal{L}_0}{\partial n_{e0}},\ \mathcal{L}_T=-\frac{1}{n_{e0}}\frac{\partial\mathcal{L}_o}{\partial T_{e0}} \qquad (24)$$

Taking divergence of equation (19) and using eq. (20) and eq. (22) we obtain

$$n_{dl} = \frac{q_d n_{d0}K^2\Phi_1}{m_d[\omega^2 + \omega_j^2 - i\omega\Omega_d]} \qquad (25)$$

where

$$\Omega_d = \frac{q_d B_0}{m_d C} \qquad (26)$$

is the dust cyclotron frequency and

$$\omega_j^2 = 4\pi\ G m_d n_{d0} \qquad (27)$$

is the Jeans frequency.

Now substituting values of n_{il}, n_{el} and n_{dl} from equation (16), (17) and (26) into the Poisson equation (21), we obtain following dispersion relation

$$\left[\omega^2 + \omega_j^2 - \Omega_d^2\right]\left[1 + i\frac{\mathcal{L}_n}{1 + K^2\lambda_{de}^2 + \frac{n_{i0}T_{e0}}{n_{e0}T_i}}\left(\Omega - i\mathcal{L}_n\right)^{-1}\right] - K^2C_s^2 = 0 \qquad (28)$$

where C_s is the dust acoustic speed and is given by

$$C_s = \left[\frac{\lambda_{de}^2\omega_{pd}^2}{\left(1 + K^2\lambda_{de}^2 + \frac{n_{i0}T_{e0}}{n_{e0}T_i}\right)}\right] \qquad (29)$$

where $\omega_{pd}^2 = 4\pi\ q_d^2\ n_{d0} / m_d, \omega_{pd}$ is the dust plasma frequency and

$\lambda_{de} = \left[T_{e0} / 4\pi\ n_{e0}e^2\right]^{1/2}$ is the Debye length of the electron.

Equation (28) represents a general dispersion relation for a self-gravitating magnetized dusty plasma incorporated thermal conductivity and heat-loss mechanism. The second term in the square bracket of this dispersion relation arises due to thermal loss. In the absence of magnetic field the dispersion relation (28) reduces to Dwivedi *et al.*[3]. Thus, we find that magnetic field parameter coupled together with dust acoustic speed. In the present case we have considered the effect of magnetic field on the radiative condensation of self-gravitating dusty plasma but Dwivedi *et al.*[3] have not considered these parameters. Thus, the dispersion relation in the present analysis is modified due to the inclusion of magnetic field and the condition of Jeans instability of

self-gravitating dusty plasma is affected by the presence of magnetic field. This is the new finding, which was not obtained earlier by Dwivedi *et al.*[3] and Tystovich and Havens[23]. It is also clear that on plotting the growth rate of our present dispersion relation (28) and the dispersion relation of Dwivedi *et al.*[3], the growth rate of the instability will be different in our present case due to the presence of magnetic field. Thus, magnetic field has an effect on the growth rate of instability of the condition (33).

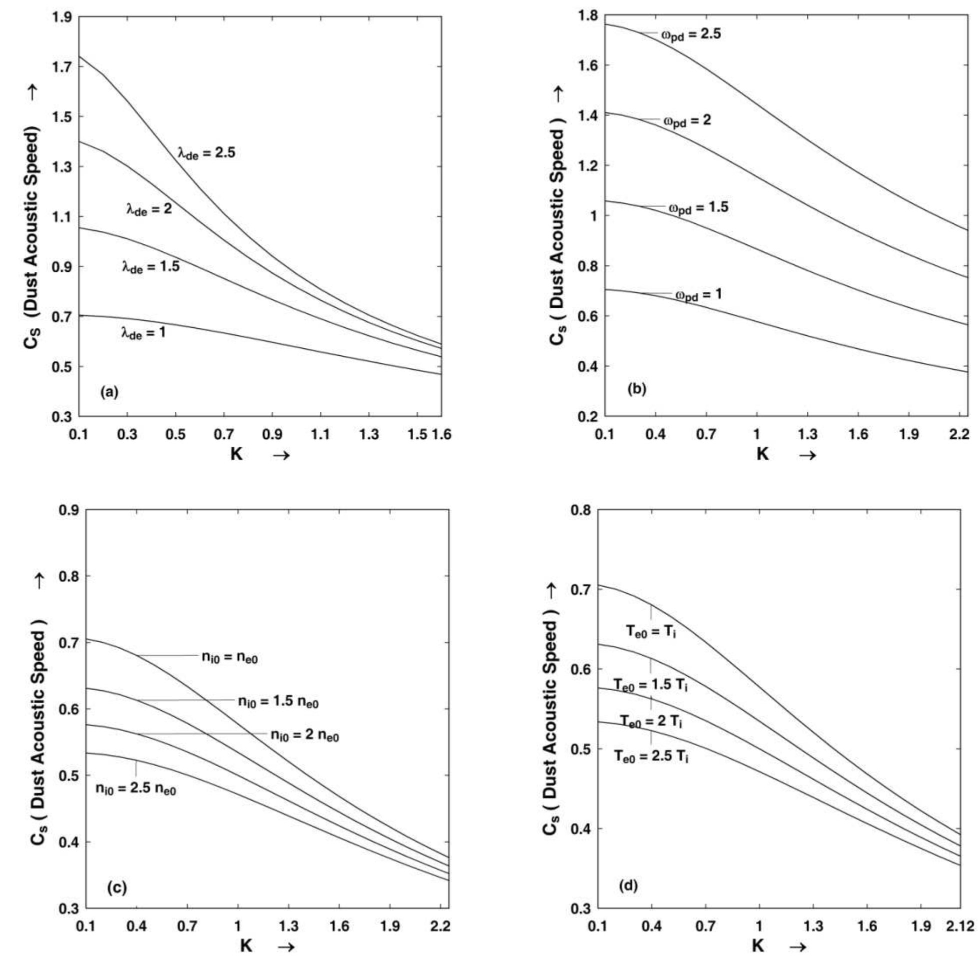

Figure 1. Variation of dust acoustic speed is plotted against the wave number with variying different parameters.(a) with the variation in debye length of Electrons λ_{de}.The values of ω_{pd}, n_{i0}/n_{e0} and T_{e0}/T_i are taken to be 1.0, 1.0 and 1.0 , respectively.(b) with the variation in dust plasma frequency ω_{pd}.The values of λ_{de}, n_{i0}/n_{e0} and T_{e0}/T_i are taken to be 1.0, 1.0 and 1.0 respectively.(c) with the variation in number density ratio n_{i0}/n_{e0}.The values of λ_{de}, ω_{pd} and T_{e0}/T_i are taken to be 1.0, 1.0 and 1.0 , respectively.(d) with the variation in particle temperature ratio T_{e0}/T_i.The values of λ_{de}, ω_{pd}, and n_{i0}/n_{e0} are taken to be 1.0, 1.0 and 1.0 , respectively.

In the ISM, structure formation is mainly due to the unstable modes, thus we study the effects of debye length of electrons, dust plasma frequency, the number density and ratio of temperature of electrons and ions on the dust acoustic speed by choosing the arbitrary values of these parameters in the present problem. The variation of dust acoustic speed with wave number for different values of various parameters is shown in figure. 1(*a*) - (*d*).

Figure. 1(*a*) is plotted for the dust acoustic speed (DAS) against the wave number with variation of debye length of electrons. We find that the dust acoustic speed increases with increase in debye length of electrons. The rate of increase in dust acoustic speed with increasing debye length at low value of wave number is very high and these rates falls rapidly at high value of wave number. Hence the debye length of electron increases the dust acoustic speed.

Similarly in figure. 1(*b*), we have depicted the dust acoustic speed against wave number for different values of dust plasma frequency. From the curves we find that the dust acoustic speed increases with increase in dust plasma frequency and the rate of increase in dust acoustic speed with variation in dust plasma frequency is high but fall of this rate at high value of wave number is slow as compared to figure. 1(*a*).

In figure. 1(*c*) the effect of number density on the dust acoustic speed is shown by depicting the curves between C_s and K for various values of number density of ions as compared to number density of electrons. We find that the dust acoustic speed increases with increase in ratio of number density of ions and electrons and the rate of increase in dust acoustic speed with variation of ratio of two number densities decreases rapidly as the wave number increases. Hence the density of ions has increasing influence on the dust acoustic speed.

Figure. 1(*d*) depicts the influence of ratio of temperature of two species i.e. (T_{e0}/T_i) on the dust acoustic speed by showing the curves between C_s and K for different values of (T_{e0}/T_i). We find that the dust acoustic speed increase with increase in (T_{e0}/T_i) and this rate with variations of (T_{e0}/T_i) decreases rapidly as the wave number increases. Hence the ratio of temperature (T_{e0}/T_i) has also increasing influence on the dust acoustic speed.

From equation (28), particular cases may be reduced as given follows, for thermally non-conducting non-radiating, self-gravitating and unmagnetized dusty plasma $\Omega_d = 0$, $\mathcal{L}= 0$ and letting $i\omega = \sigma$, then dispersion relation (28) becomes

$$\sigma^2 + K^2 C_s^2 - \omega_j^2 = 0 \tag{30}$$

which leads to Jeans instability

$$K < K_j = \left[\frac{4\pi\, G\, m_d n_{d0}}{C_s^2} \right]^{1/2} \tag{31}$$

Inequality (31) represents Jeans criterion of instability for dusty plasma and K_j is critical jeans wave number. The system represented by equation (30) is unstable for all the wave number $K<K_j$.

For unmagnetized self-gravitating dusty plasma incorporating heat-loss term and for our convenience, taking limit $\omega \ll \mathcal{L}_n$, $\mathcal{L}_T$, χK^2 dispersion relation (28) reduces to

$$\sigma^2 + \frac{K^2 C_s^2}{1-\alpha} - \omega_j^2 = 0 \tag{32}$$

here α is defined as, $\alpha = \dfrac{\mathcal{L}_n}{\mathcal{L}_n + \mathcal{L}_T - \chi K^2}$.

Equation (32) leads to monotonic instability as

$$K < K_{j1} = \left[\frac{4\pi\, G m_d n_{d0}(1-\alpha)}{C_s^2}\right]^{1/2} \tag{33}$$

Comparing conditions in eq. (31) and eq. (33), we find that Jeans instability is modified due to heat-loss term of the dusty plasma.

For a self-gravitating unmagnetized plasma in the absence of dust grains. For our convenience, taking limit $K\lambda_{de} \ll 1$, we have from eq. (28) as

$$\sigma = -\frac{2}{3}\left[\frac{\mathcal{L}_n}{2} + \mathcal{L}_T - \chi K^2\right] \tag{34}$$

This is usual radiative condensation instability. For self-gravitating magnetized dusty plasma in the absence of heat-loss term, we have from eq. (28) as

$$\sigma^2 + \Omega_d^2 + K^2 C_s^2 - \omega_{jd}^2 = 0 \tag{35}$$

which gives instability if $K<K_{j2}$ where

$$K_{j2} = \left[\frac{4\pi G m_d n_{d0} - \Omega_d^2}{C_s^2}\right]^{1/2} \tag{36}$$

If we compare condition (31) and (36), it is obvious that the magnetic field decreases the Jeans wave number. Thus, the magnetic field stabilizes the dusty plasma for transverse propagation.

For self-gravitating magnetized dusty plasma incorporating heat-loss term and taking limit $\omega \ll \mathcal{L}_n$, $\mathcal{L}_T$, χK^2 dispersion relation (28) becomes

$$\sigma^2 + \Omega_d^2 + \frac{K^2 C_s^2}{1-\alpha} - \omega_{jd}^2 = 0 \tag{37}$$

Equation (37) leads to monotonic instability if $K<K_{j3}$ where

$$K_{j3} = \left[\frac{(1-\alpha)\left(4\pi G m_d n_{d0} - \Omega_d^2\right)}{C_s^2}\right]^{1/2} \tag{38}$$

Thus, it is clear from equation (38) that critical Jeans wave number is modified by magnetic field and heat-loss term. The dispersion relation (37) may be represented in a non-dimensional from in terms of self – gravitation as

$$\sigma^{*2} + \Omega_d^{*2} + \frac{K^{*2}}{1-\alpha} - 1 = 0 \tag{39}$$

where the various non-dimensional parameters are defined as

$$\sigma^* = \frac{\sigma}{\sqrt{4\pi G m_d n_{d0}}},\quad K^* = \frac{K C_s}{\sqrt{4\pi G m_d n_{d0}}} \text{ and}$$

$$\Omega^*_d = \frac{\Omega_d}{\sqrt{4\pi G m_d n_{d0}}}$$

In order to study the influence of various physical parameters on the growth rate of unstable mode, we have performed numerical calculations of the dispersion relation (38) to locate the root of σ * (growth rate) for several values of the parameters. These calculations are plotted in figure 2, 3 and 4.

In figure 2, we have depicted the non-dimension growth rate (σ *) versus non dimensional wave number (K*) for various arbitrary values of ratio of derivative of purely density - dependent heat loss function to sum of derivatives of purely density - dependent heat-loss function and purely temperature - dependent heat-loss function$\alpha = \mathcal{L}_n / (\mathcal{L}_n + \mathcal{L}_T)$ for thermally non-conducting medium ($\lambda^* = 0$) in the presence of magnetic field parameter kept constant i.e. arbitrary value Ω_d*= .5. The curve depicts for α = 0, i.e. the density independent heat-loss function, we find the non-dimensional growth rate (σ*) rapidly decreases with increase in non-dimensional wave number (K*). Hence for thermally non-conducting and density-independent heat-loss function, the system tends towards a more stable situation with increasing K*. The curve for α = 1 shows the influence of a purely density - dependent heat - loss function $\mathcal{L}_n^*$= 0.0, $\mathcal{L}_\rho^*$= 0.5, which increases with increasing density. It is obvious that for a purely density - dependent heat loss and adiabatic medium, the non-dimensional growth rate (σ*) rapidly increases with increasing in non dimensional wave number (K*). Hence the density dependent heat-loss function has a destabilizing influence on the growth rate of instability. The curves for α =1.5($\mathcal{L}_T^*$= 1.66, $\mathcal{L}_n^*$= 0.5) and α=2($\mathcal{L}_T^*$= 0.25, $\mathcal{L}_n^*$= 0.5), which increases with increasing density and with increasing temperature are depicts the combined effect of derivatives of density-dependent heat-loss and temperature- dependent heat-loss function. On the non-dimensional growth rate against non-dimensional wave number (K*) for an adiabatic medium. From these curves, it is found that the non-dimensional growth rate (σ*) increases with increasing in non-dimensional wave number (K*) but the rate of growth is decreases with including temperature dependent heat-loss and it is further decreased by the increasing temperature dependent $\mathcal{L}_T^*$, which increases with increasing temperature. From these curves, we find that the density dependent heat-loss has a destabilizing influence on the growth rate of instability where as the temperature -dependent heat-loss function has a stabilizing influence on the growth rate of instability.

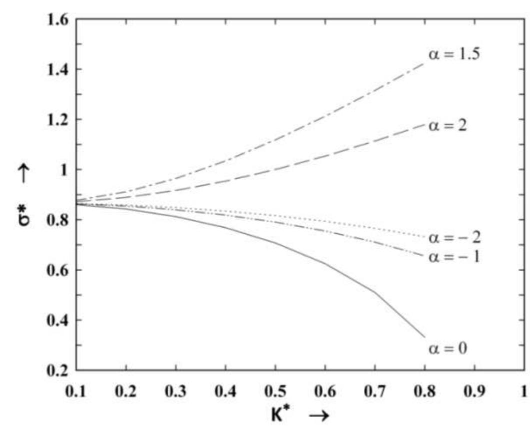

Figure 2. The growth rate (Positive real value of σ*) is plotted against the non dimensional wave number K^* with variation in normalized radiative heat-loss function ($\mathcal{L}_T^*$, $\mathcal{L}_\rho^*$) i.e. the values of α. The values of constant parameters χ and Ω_d^* are taken to be 0.0 and 0.5, respectively.

The combined effect of density dependent and temperature dependent heat loss function, which increases with increasing in density and decreases with increasing in temperature are shown by curves α = –1($\mathcal{L}_T^*$= –1.0, $\mathcal{L}_n^*$= 0.5), α = –2($\mathcal{L}_T^*$= –.75, $\mathcal{L}_n^*$= 0.5). It is clear from the

curves that if the system behaves adiabatically, the non-dimensional growth rate (σ*) decreases with increasing in non-dimensional wave number (K*). It is obvious that for an adiabatic medium the system tends towards a more stable situation with increasing K* and it is more effective with the negative arbitrary value of $\mathcal{L}_T^*$ i.e. (temperature - dependent heat loss function decreases with increasing temperature).

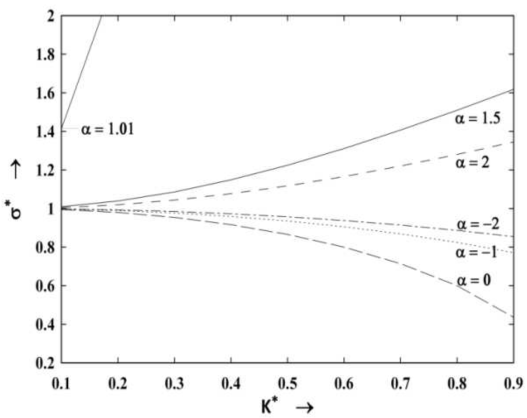

Figure 3. The growth rate (Positive real value of σ*) is plotted against the non dimensional wave number K^* with variation in normalized radiative heat-loss function ($\mathcal{L}_T^*$, $\mathcal{L}_\rho^*$) i.e. the values of α. The values of constant parameters χ and Ω_d^* are taken to be 0.0 and 0.0, respectively.

In figure 3 we have depicted the non-dimensional growth rate (σ*) versus non-dimensional wave number (K*) for various arbitrary values of α (the ratio of derivative of purely density dependent heat-loss function to sum of derivatives of purely density-dependent heat-loss function and purely temperature dependent heat-loss function for an adiabatic system (χ = 0) in the absence of magnetic field parameter Ω_d* = 0.0.The pattern of curves for α = 0, –1, –2, 1, 1.5 and α = 2 are similar as obtained in figure 2 in the presence of magnetic field parameter but in these curves, the initial value of non-dimensional growth rate is more than that of curves in figure 2.Thus magnetic field parameter stabilizes the system.

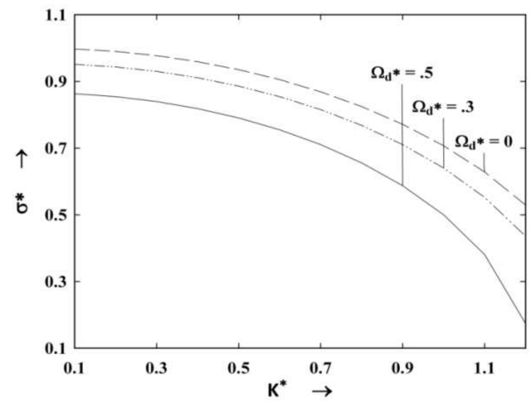

Figure 4. The growth rate (Positive real value of σ*) is plotted against the non dimensional wave number K^* with variation in the magnetic field Ω_d^*. The values of constant parameters χ and α are taken to be 0.0 and -1.0, respectively.

In figure 4, the effect of magnetic field parameter on the growth rate is shown by depicting the curves between σ* and K* for various value of Ω_d^* for an adiabatic medium (χ = 0) with constant value of α = –1($\mathcal{L}_T^*$= –1.0, $\mathcal{L}_n^*$= 0.5). It is clear from curves that the non-dimensional growth rate (σ*) decreases with increasing non-dimensional wave number (K*) and this is further decreases by increasing the value of magnetic field parameter. Hence the magnetic field has a stabilizing influence on the growth rate of instability.

On analysing the critical Jeans number relation (33), we find that the critical Jeans wave number have influence of the

ratio of purely density dependent heat loss function to sum of purely density dependent and temperature dependent heat-loss function. The value of critical Jeans wave number decreases with increasing density dependent heat-loss function which increases with increasing in density.

CONCLUSIONS

In the present paper, we have investigated the effect of radiative condensation on Jeans instability of self-gravitating dusty plasma in the presence of an external transverse magnetic field, it is assumed that the fluid is a three component plasma having electrons, ions and charged dust grains. The ions and electrons are assumed inertia less and the ions have infinite large thermal conductivity but electrons have finite thermal conductivity. We have considered the quasineutral equilibrium. In this equilibrium there is no electric field and the free energy is solely due to gravitational field of the self-gravitating dust grains. With the help of relevant linearized perturbation equations of the problem, a general dispersion relation is obtained, which is modified due to the presence of thermal conductivity parameter, the derivative of density-dependent and temperature dependent heat-loss function magnetic field parameter and dust acoustic speed. We find that the Jeans condition remains valid but the expression of the critical Jeans wave number is modified. It is observed that the magnetic field decreases the critical jeans wave number, thus the magnetic field have a stabilizing influence on the Jeans instability of the dusty plasma for transverse propagation. Owing to the inclusion of thermal conductivity the isothermal sound velocity is replaced by the adiabatic velocity of sound. We also find that the thermal conductivity has a destabilizing influence on the growth rate of the system. The value of critical Jeans wave number decreases with increasing the parameter of thermal conductivity. It is also found that critical Jeans wave number is affected by density- dependent and temperature dependent heat loss function. The critical Jeans wave number decreases with increasing the density-dependent heat-loss function. Thus, the density-dependent heat loss function destabilizes the system.

From the curves it is found that the dust acoustic speed increases with increase in Debye length of electrons and increase in dust plasma frequency. In both the case the rate of increase in dust acoustic speed at low value of wave number and this rate falls rapidly at high value of wave number. We also find that the dust acoustic speed increases with decrease in ratio of number densities of ions and electrons,(n_{i0}/n_{e0}) decrease in ratio of temperature of two species (T_{e0}/T_i) and the rate of increase in dust acoustic speed at low K^* and this rate falls rapidly at high value of K^*.

For the adiabatic system curves shows that the growth rate decreases by increasing the value of magnetic field parameter, thus the magnetic field has a stabilizing influence on the growth rate of instability of the system in the transverse direction. The growth rate increases with increasing wave number for purely density dependent heat-loss function ($\alpha \rightarrow 1$), it is obvious that purely density-dependent heat-loss has a destabilizing influence on the growth rate of instability of the system. From the curves it is observed the combined

effect of density dependent and temperature-dependent heat loss function affects the growth rate of instability. The growth rate of instability increases with increasing in derivative of temperature-dependent heat loss function which increases with increasing in temperature of the system with a constant value of density- dependent heat-loss function. In the case of temperature-dependent heat loss function, which decreases with increasing in temperature, the growth rate decreases with increasing wave number. Thus cooling effect of the system has a stabilizing influence on the growth rate of instability. Thus, radiative condensation of magnetized dusty plasma plays an important role in the process of gravitational collapse.

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